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Simulator Sickness in the MH-47G Simulator

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14. ABSTRACT
The objective of this study was to quantify the symptoms of simulator sickness induced by the MH-47G simulator, and to provide recommendations to alleviate simulator sickness if the MH-47G was found to generate unacceptable levels of simulator sickness. The Simulator Sickness Questionnaire (SSQ) was used to determine the extent and severity of simulator sickness symptoms experienced by the aviators. A total of 232 SSQ's were included in the analysis. The MH-47G simulator produced negligible symptoms of simulator sickness as the mean total SSQ score was less than five, both when the simulator was on- and off-motion. The present study did illustrate the individual differences in simulator sickness susceptibility in response to simulator motion.

15. SUBJECT TERMS
simulator sickness, Simulator Sickness Questionnaire, simulator motion

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Introduction

Recently, the 160th Special Operations Aviation Regiment (SOAR) expanded its simulation and training capabilities with the acquisition of the AH/MH-6 Little Bird and MH-47G Chinook simulators. During its first year of use, there were significant reports of simulator sickness with the AH/MH-6 simulator, and the U.S. Army Aeromedical Research Laboratory (USAARL) was asked to assess the problem. An analysis of data collected from aviator reports (i.e., symptoms reported from simulated flight) suggested the AH/MH-6 was a problem simulator which generated complaints of simulator sickness at unacceptable levels (Grandizio, Bass, & Wildzunas, 2008). Currently, it is undergoing upgrades to the visual system requiring significant down time. To avoid similar consequences, the Commander has requested the MH-47G simulator be monitored for signs of simulator sickness to prevent any negative impacts on flight training, and once again asked USAARL to examine the data.

Simulator sickness is a form of motion sickness caused by physical motion, visual motion, or some combination of the two in a simulator. Compared to motion sickness, the symptoms of simulator sickness tend to include more visual disturbances than gastrointestinal manifestations. Symptoms include dizziness, nausea, eyestrain, feelings of warmth, headache, disorientation, and fatigue (Johnson, 2005). In accordance with Army Regulation 40-8 (Department of the Army, 2007), aircrew exhibiting symptoms of simulator sickness are restricted from actual flight for 12 hours after all symptoms completely resolve. Simulator sickness has a negative impact on military aviation training, including reduced simulator use, ineffective simulator training, and compromised ground and air safety. For example, if a simulator induces simulator sickness symptoms, aviators may develop “bad habits” (e.g., limiting head movements or even closing their eyes during certain maneuvers) which may carry over to actual flight and have devastating consequences (Crowley, 1987).

Objective

The objective of this study was to quantify the symptoms of simulator sickness induced by the MH-47G simulator, and to provide recommendations to alleviate simulator sickness if the MH-47G was found to generate unacceptable levels of simulator sickness.

Methods

The Simulator Sickness Questionnaire (SSQ) was used to determine the extent and severity of simulator sickness symptoms experienced by the aviators. Developed by Kennedy, Lane, Berbaum, and Lilienthal (1993), the SSQ is a self-report checklist consisting of 16 symptoms that are rated by the participant in terms of severity (see appendix). These symptoms include, but are not limited to headache, nausea, burping, sweating, fatigue, and vertigo. Participants rate each symptom on a Likert-type scale, including the options “none,” “slight,” “moderate,” and “severe.”

The SSQ was derived from the Pensacola Motion Sickness Questionnaire (MSQ), which reports a single, composite score. The SSQ is comprised of three subscales, namely nausea, disorientation, and oculomotor distress, as well as an overall total simulator sickness score. The nausea scale contains symptoms such as increased salivation, nausea, stomach awareness, and burping. Symptoms included in the oculomotor scale include headache, eyestrain, and blurred vision, while symptoms included in the disorientation scale include nausea, dizziness (with eyes open or closed) and vertigo.

To obtain the scores, first values are assigned to the severity of the symptoms. For example, a rating of “none” on the fatigue symptom would equal a value of 0 for that symptom. A rating of “slight” would equal a value of 1, “moderate” would equal a value of 2, and “severe” would equal a value of 3. The values for the symptoms included in the specific scale are summed and then multiplied by a unique conversion factor. The total simulator sickness score sums each subscale score (before the conversions) and applies its own conversion formula to this sum. Scores for the nausea scale range from 0 to 200, scores on the oculomotor scale range from 0 to 159, scores on the disorientation scale range from 0 to 292, and total simulator sickness scores range from 0 to 235. The higher the score, the greater the severity of the symptoms, and thus, the greater the simulator sickness. For example, a total score of 20 indicates perceptible discomfort, whereas a total score over 100 indicates that a person is actively ill (Kennedy, et al., 1993).

The present study focused on the assessment of the MH-47G simulator which has a six-degree freedom of motion platform and a three-degree vibration platform. It features a collimated display system with a 210 by 65 degree field-of-view (figure 1). Interestingly, data was collected from training periods in which the motion platform was utilized (i.e., the simulator was “on-motion”) and also when the simulator was stationary (“off- motion”), allowing for the assessment of the role of motion in simulator sickness.

Figure 1. The MH-47G simulator (CAE website)

The study protocol was approved by USAARL’s Human Use Committee, and the data were delivered to USAARL de-identified. Participants were rated H-47 pilots located at Fort Campbell, KY. Everyone who used the MH-47G simulator during the data collection period (January to June 2008) was asked to complete the SSQ immediately after their simulator session. To reduce issues with response bias, all pilots were asked to complete a SSQ after every session, even if they did not experience any symptoms. Each simulator session lasted approximately two hours.

Results

A total of 232 SSQ's were included in the analysis. The SSQ's were completed by 39 aviators, ranging in age from 25 to 52 years (*M* = 36.1, *SD* = 7.3). The average number of flight hours for the participants was 2380.3 (*SD* = 1659.3), with a range of 486 to 9000 total hours. The data were analyzed separately according to whether the MH-47G simulator was on- or off-motion. From January-April 2008, the MH-47G was on-motion. During that time, a total of 194 SSQ's were completed by 27 aviators. Of those 27 pilots, 12 reported at least one symptom of SS (44.4 percent incidence). From May-June 2008, the MH-47G was off-motion. A total of 38 SSQ's were completed by 18 aviators. Of those 18 pilots, 3 reported at least one symptom of SS (16.6 percent incidence). The most frequently reported symptoms are presented in table 1.

Table 1.
Most commonly reported symptoms of simulator sickness.

SSQ Symptom	Frequency on-motion	Frequency off-motion
General Discomfort	8	2
Fatigue	2	0
Headache	12	1
Eye Strain	16	0
Difficulty Focusing	7	1
Increased Salivation	2	2
Sweating	4	1
Nausea	4	2
Difficulty concentrating	3	0
Fullness of the head	5	0
Blurred vision	3	0
Dizziness with Eyes Open	2	0
Dizziness with Eyes Closed	0	0
Vertigo	0	2
Stomach Awareness	3	2
Burping	2	0

The mean subscale and total SSQ scores are reported in table 2. According to the scoring criteria of Stanney, Kennedy, and Drexler (1997), the MH-47G simulator produces negligible symptoms of simulator sickness as the mean total SSQ score was less than five. In addition, the profiles of the three subscales changed in response to whether or not the simulator was on-motion. When the simulator was on-motion, oculomotor scores were the highest. However, when the simulator was off-motion, nausea scores were higher.

Table 2.
SSQ scores from the MH-47G simulator.

	SSQ Subscale	Mean Score	Standard Error
On Motion			
	Nausea	1.377	0.418
	Oculomotor	2.032	0.473
	Disorientation	1.546	0.449
	Total	1.966	0.464
Off Motion			
	Nausea	2.259	1.459
	Oculomotor	0.798	0.382
	Disorientation	1.832	1.304
	Total	1.772	1.044

An independent samples *t* test was used to assess the role of simulator motion on SSQ scores for the MH-47G data. Results from the analysis are presented in table 3. It should be noted that due to the unequal number of SSQ's collected from when the simulator was on- and off-motion, equal variance was not assumed. The mean oculomotor SSQ scores were significantly higher when the simulator was utilizing motion (M = 2.032) than when it was not on motion (M = 0.798).

Table 3.
Results from independent samples *t* test.

SSQ Subscale	*t*	*df*	*p*
Nausea	-0.582	43.278	0.564
Oculomotor	2.027	163.631	0.044*
Disorientation	-0.207	46.154	0.837
Total	0.171	52.682	0.865

Note: * indicates a statistically significant difference

Discussion

The results of the SSQ data suggest that the MH-47G simulator produces negligible symptoms of simulator sickness. The incidence rates of 16.6 and 44.4 percent are consistent to other incidence rates published in the literature for military flight simulators. In Crowley (1987), a 40 percent incidence was found in the AH-1 Cobra simulator. In addition, Gower et al., (1987) found a 44 percent incidence rate in their analysis of the AH-64 Apache simulator. Other reviews of rotary wing flight simulators found the incidence of simulator sickness ranged from 13 to 70 percent (Wright, 1995). Rotary wing aircraft are known to cause higher rates of simulator sickness compared to fixed wing aircraft (Johnson, 2005).

In addition, much can be learned from an analysis of the subscale profiles. When the MH-47G simulator was on-motion, oculomotor symptoms predominated, which is commonly seen in simulator sickness (Kennedy & Fowlkes, 1992). However, when the simulator was off-motion, nausea symptoms were more common. The difference in SSQ subscales highlights the importance of motion in simulator sickness. Simulator sickness does not require the presence of motion, as a moving visual field is able to produce the feeling of self motion (e.g., vection). This is best explained by the sensory conflict theory, which claims that motion or simulator sickness results when the senses (vision, vestibular, proprioceptive systems) perceive conflicting motion information (Reason & Brand, 1975). In the case of simulator sickness, the visual system perceives a moving environment from the field-of-view, while the vestibular system does not detect motion. Several field guides recommend turning off the motion to reduce simulator sickness (NTSC, 1988). This practice has the potential to *increase* simulator sickness due to the sensory conflict depending on the visual scene and the amount of vection produced. In the present study, turning off the simulator motion resulted in increased mean nausea SSQ scores but lower mean oculomotor scores. A comparison of the six individuals who completed simulator flights both on- and off-motion revealed great individual differences with regard to the effects of motion on simulator sickness. Half of the individuals reported greater SSQ scores when the simulator was on-motion, while the other half reported no symptoms of simulator sickness regardless of whether the simulator was on- or off-motion.

Discussion with visual engineers regarding the MH-47G simulator indicated that its collimated display prevented the simulator sickness problems seen with the AH/MH-6 simulator (Grandizio, Bass & Wildzunas, 2008). Simulators with collimated displays often produce less parallax, a factor known to increase simulator sickness (Johnson, 2005). The MH-47G simulator uses a mirror and a projection screen to make the light rays appear to be parallel from a fixed source (Tiron, 2004).

The change in oculomotor SSQ scores from when the simulator was on- and off-motion was unexpected. Discussions with MH-47G simulator operators indicated the simulator did not experience any upgrades to the visual system during the data collection that may have confounded the results. A review of the literature failed to find similar cases in which oculomotor scores decreased in response to a stationary simulator. Although the change was statistically significant, the scores were very low when the simulator was both on- and off-motion, indicating very negligible simulator sickness for both settings.

Limitations

This study has some important limitations that should be noted. As with all survey research, there may be the possibility of a response bias in which pilots that experienced simulator sickness symptoms were more likely to complete the SSQ. To reduce this bias, it was stressed to the pilots to complete a questionnaire after every session, even if they did not experience any symptoms. In fact, approximately 80 percent of the surveys indicated a pilot had no symptoms but still completed a SSQ.

In addition, simulator sickness is known to produce aftereffects, like loss of balance and nausea, even six hours after the simulator session (Johnson, 2005). Estimates claim that approximate 10 percent of pilots will experience aftereffects that will last for several hours (Kennedy & Fowlkes, 1992). Although rare, these aftereffects can compromise air and ground safety. In the present study, we only asked pilots to complete a SSQ immediately after their simulator session. Therefore, we cannot make any claims regarding the rate of aftereffects for the present study.

Conclusion

The results of the SSQ data suggest that the MH-47G simulator produced negligible simulator sickness symptoms, both on- and off-motion. The present study did illustrate the individual differences in simulator sickness susceptibility in response to simulator motion. The advances in the collimated displays appear to have improved the image quality associated with simulators with wide fields-of-view.

References

Crowley, J. S. 1987. Simulator sickness: A problem for Army aviation. Aviation, Space, and Environmental Medicine. 58(4): 355-357.

Department of the Army. 2007. Temporary flight restrictions due to exogenous factors. Washington, D.C. AR 40-8.

Gower, D. W., Lilienthal, M. G., Kennedy, R. S., Fowlkes, J. E., & Baltzley, D. R. 1987. Simulator sickness in the AH-64 Apache Combat Mission Simulator. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Report No. 88-1.

Grandizio, C.M., Bass, J.M., & Wildzunas, R.M. 2008. Simulator sickness in the AH/MH-6 (Little Bird) Simulator. Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL Technical Memorandum No. 2008-05.

Johnson, D. M. 2005. Introduction to and review of simulator sickness research. Arlington, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. ARI Research Report 1832.

Kennedy, R. S., & Fowlkes, J. E. 1992. Simulator Sickness is polygenic and polysymptomatic: Implications for research. International Journal of Aviation Psychology. 2(1): 23-38.

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. 1993. Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. International Journal of Aviation Psychology. 3(3): 203-220.

NTSC. 1988. Simulator sickness field manual mod 3. Orlando, FL: Naval Training Systems Center.

Reason, J. T. & Brand, J. J., eds. 1975. Motion sickness. New York: Academic Press.

Stanney, K. M., Kennedy, R. S., & Drexler, J. M. 1997. Cybersickness is not simulator sickness. Proceedings of the Human Factors and Ergonomics Society 41st Annual Meeting. 2: 1138-1142.

Tiron, R. 2004. Special ops aviators press industry to improve trainers. National Defense. Retrieved 7 April 2008 from http://goliath.ecnext.com/coms2/gi_0199-704519/Special-ops-aviators-press-industry.html

Wright, R. H. 1995. Helicopter simulator sickness: A state-of-the-art review of its incidence, causes, and treatment. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. ARI Research Report 1680.

Appendix

Simulator Sickness Questionnaire.

Simulator Sickness Questionnaire- MH-47G Simulator
(9 Jan 08)

For each symptom, please circle the rating that applies to you **RIGHT NOW**.

Please complete even if you have no symptoms

SYMPTOM	**RATING**			
general discomfort	none	slight	moderate	severe
fatigue	none	slight	moderate	severe
headache	none	slight	moderate	severe
eye strain	none	slight	moderate	severe
difficulty focusing	none	slight	moderate	severe
salivation increased	none	slight	moderate	severe
sweating	none	slight	moderate	severe
nausea	none	slight	moderate	severe
difficulty concentrating	none	slight	moderate	severe
“fullness of the head”	none	slight	moderate	severe
blurred vision	none	slight	moderate	severe
dizziness with eyes open	none	slight	moderate	severe
dizziness with eyes closed	none	slight	moderate	severe
vertigo	none	slight	moderate	severe
stomach awareness	none	slight	moderate	severe
burping	none	slight	moderate	severe
other (please describe)				

Additional Questions

1. Have you eaten prior to entry into simulator? Yes/no (circle one) if so, when?__________

2. Do you wear corrective lenses? Yes/no (circle one) if so, type?_________

3. Do you have previous experiences of motion/simulator sickness? Yes/no (circle one) if so, when was the last occurrence?___________

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